

NASA Technical Memorandum 104754

## The Locator System for Wandering Individuals

Shayla Davidson  
*Lyndon B. Johnson Space Center*  
*Houston, Texas*

National Aeronautics and Space Administration  
Lyndon B. Johnson Space Center  
Houston, Texas

August 1992

[illegible]

**CONTENTS**

Section	Page
INTRODUCTION	1
DEFINITION OF WANDERING BEHAVIOR	1
IMPACT OF WANDERING PROBLEMS	2
COPING STRATEGIES	2
EXISTING DEVICES	3
APPROACH	3
CONCEPT AND FUNCTIONAL REQUIREMENTS FOR A HOME WANDERING SYSTEM	3
DESIGN OF THE LOCATOR SYSTEM FOR WANDERING INDIVIDUALS	5
CONCLUSION	17
REFERENCES	18



## FIGURES

Figure		Page
1	Home Wandering System - The Safe Perimeter (Davidson et al, 1989)	4
2	Home Wandering System - Passageway Detection (Davidson et al, 1989)	5
3	Home Wandering System Configuration	6
4	Central Processing Unit for Institutional Wandering System	7
5	Sensors for Institutional Wandering System	7
6	Sample Facility Floor Plan	9
7	Sample Facility Floor Plan - Low Battery Condition	11
8	Patient Database	13
9	Institutional Wandering System Test Program	14
10	Portable Homing Unit	15
11	Identification Tag	16
12	Packaging of Identification Tag Components	16



## INTRODUCTION

Space technology has been applied to the problems of memory loss in today's aging population as part of the NASA Applications Engineering Program. This project was sponsored by the National Aeronautics and Space Administration, the Administration on Aging, the National Institute on Aging, the Veterans' Administration, and the National Institute on Disability and Rehabilitation Research. The mission of these Federal agencies was to combine their expertise and resources to identify and support technology-based solutions to problems faced by the aging population. The first project under this joint effort called for developing a "memory aid" device. The recommended target population was the clinically mild to moderately impaired elderly suffering from Alzheimer's disease, dementia, or stroke. Memory impairment problems were narrowed to wandering and orientation.

The data collected during a needs assessment study documented the problem of memory loss in the aging population. NASA and the four health agencies then chose to focus on the problem of wandering behavior and assigned the project to the NASA Johnson Space Center based on the center's expertise in microelectronics and communication and tracking systems. A competitive contract was awarded to Cortex Electronics, Inc., and the design and prototype system development for the Locator System for Wandering Individuals were completed.

## DEFINITION OF WANDERING BEHAVIOR

There is variation in terms of what specific behavior is defined as wandering, and this behavior may present itself differently in the home and institutional settings. To understand the problem and to develop a means for helping those who wander and their caregivers requires an understanding of the factors that contribute to wandering or that characterize those who wander.

The most important contributing element is memory impairment, but environment also plays a significant role. Memory-impaired older people may walk to escape stressful environments, to obtain physical or emotional stimulation, or because environmental cues fail to direct them to places they are trying to find (Burnside, 1980; Hiatt, 1980; Lawton, 1981; Hiatt, 1980; Hiatt, 1982). In addition, an important element in at least some wandering is the person's sense of need to go somewhere — to a prior home, a former workplace, or some other location (Rader et al., 1985).

For the purposes of this project, wandering was defined as movement by a memory-impaired older person, either outside or within the home (or institutional setting), that puts the person in danger of harm. The two major forms are

- Wandering away from the home (or institution) and being unable to find the way back
- Wandering within the home (or institution) into areas that are unsafe or inappropriate for the person to be in, during times when the caregiver cannot readily provide needed supervision.

## **IMPACT OF WANDERING PROBLEMS**

On the basis of clinical experience, practitioners estimate that 15 to 20 percent of dementia patients in the community outside of institutions wander away from home or attempt to wander away (Cohen, 1986). A recent study of 501 family caregivers of older persons suffering from Alzheimer's disease or a related disorder found that 81 percent of the patients had wandered away from home or within the home at some time since they first showed signs of the disease, and 38 percent had done so frequently (George, 1983). These figures, applied to an estimated 1.0 to 1.3 million older people with dementia living in the community outside of institutions (U.S. Bureau of the Census, 1984; Katzman, 1985), suggest that between 200,000 and 494,000 people may wander away from or within the home. These numbers will undoubtedly increase with the growth of the older population.

Wandering affects the quality of life of persons with wandering problems in both positive and negative ways. On the positive side, it can allow the person to relieve tension, to seek variety and stimulation in the environment, to benefit from physical exercise, and to participate in social interactions. Appropriately directed and managed, wandering within a safe setting may help the person maintain a sense of independence and control.

Negative direct impacts of wandering include physical danger from traffic, bad weather, hazards such as lakes and pools, and even attacks by hostile people (Mace and Rabins, 1981). There are also indirect impacts resulting from constant vigilance on the part of the caregiver, physical or chemical restraint, and the use of locks or other barriers on doors, or notification schemes (bells, alarms). Wandering can be an important factor in a family's decision to seek nursing home or other institutional placement for an elderly relative (Mace and Rabins, 1981; Hiatt, 1985; Oakley, 1965; Brody, 1981).

For home caregivers, the impact of wandering behavior is substantial and important in itself. The home caregiver's major distress is his or her fear of what may happen to a memory-impaired family member who wanders away from home. This distress is typically felt even if the older person wanders infrequently.

The impact of wandering on older persons combined with the impact on their caregivers provides the basis for examining approaches used in coping with home wandering, and for describing key features of a new system for wandering notification.

## **COPING STRATEGIES**

Probably the single most important coping strategy, used alone or in combination with other approaches, is constant vigilant surveillance by the caregiver. Physical restraints, although sometimes used in institutional settings (Burnside, 1980; Miller, 1976; Cornbleth, 1977; Snyder et. al., 1978; Fennelly, 1985), are probably less widely used by home caregivers. Home caregivers have other coping strategies available, including simply locking all the doors. Chemical restraints, on the other hand, such as sedatives, tranquilizers, or other medications, may be more frequently used by some home caregivers than institutions to control wandering.



## EXISTING DEVICES

Manufacturers have recently begun to develop and market devices to be used in institutional and home settings as a part of comprehensive wandering management programs. Most of these devices have become available only within the past few years and are still quite limited in both their features and use, especially by home caregivers. In general, existing devices can be grouped into five classifications: (1) door monitoring systems, (2) perimeter monitoring systems, (3) door locking systems, (4) telephone response systems, and (5) personnel locators.

Technologies can also be incorporated into notification schemes for the wanderer if it is deemed effective. A design for a home wandering system should incorporate the best features of existing systems while adding features that are desirable but are not yet available. More important, any technological aid should be only a part of a comprehensive plan for managing wandering behavior.

## APPROACH

The five Federal agencies, Research Triangle Institute (RTI) project staff, and engineers at the NASA Johnson Space Center worked together to develop the applications engineering project to apply related technology to the problem of wandering. They also actively secured the involvement of Cortex Electronics, Inc., early in the process to ensure the commercial availability of products developed under this project.

Once the five Federal agencies had narrowed the problem to wandering, the RTI project staff performed the needs assessment for the home wandering system. The goal was to specify functional requirements based on user-defined needs and then to initiate an applications engineering project by NASA and a highly qualified manufacturer. The Johnson Space Center then developed a project plan, solicited proposals from industry, and chose Cortex Electronics, Inc., as the manufacturer.

## CONCEPT AND FUNCTIONAL REQUIREMENTS FOR A HOME WANDERING SYSTEM

The development of a home wandering system must consider the physical, cognitive, and social characteristics and needs of older people who wander and of their caregivers and then incorporate features designed to help meet these needs. The successful device balances freedom of movement with safety for the wanderer while providing assistance and reassurance to the home caregiver.

The concept of a wandering notification system was based on a review of the literature, a review of existing devices and notification strategies, consultation with experts in the field of memory impairment and aging, and interviews with other persons directly involved with the target population, such as administrators, physicians, and health care consultants. The concept was

then critically evaluated through focus group discussions and individual interviews with manufacturers and caregivers. The modified concept for a home wandering system is discussed here in terms of its configuration, operations strategies, core functional requirements, and recommended additional capabilities.

The wandering notification system consists of an identification (ID) tag worn by the wanderer, a passageway detector, a perimeter detector, a portable caregiver unit for use in the home, a portable homing unit, and an institutional caregiver system. The modular construction allows for different configurations based on the environment and on the needs of the older person and the caregiver. The ID tag is a small transceiving (transmitting and receiving) device that is capable of notifying the caregiver and/or the wanderer at the onset of a wandering incident. The caregiver's unit is a portable transceiving device used to notify the caregiver when the wanderer goes beyond a safe range or is entering an unsafe area. The passageway detector is a door-mounted device capable of detecting the approach or passage of the ID tag. This unit could be placed at a door leading outside or where the wanderer could enter a restricted area, such as a kitchen or stairway. Notification occurs when the ID tag travels out of communication range with a perimeter detector or when a passageway detector signals the presence of the ID tag.

Figures 1 and 2 show two operational strategies for the home wandering system. In figure 1, the caregiver allows the wanderer freedom of movement only within a safe perimeter, which may be the front yard or sidewalk. Here, the ID tag and the caregiver's unit can be used to notify the caregiver and possibly the wanderer if the wanderer has attempted to travel beyond the safe perimeter. The configuration in figure 1 would also permit different ranges for individual users as well as provide potential training of safe movements for the wanderer.

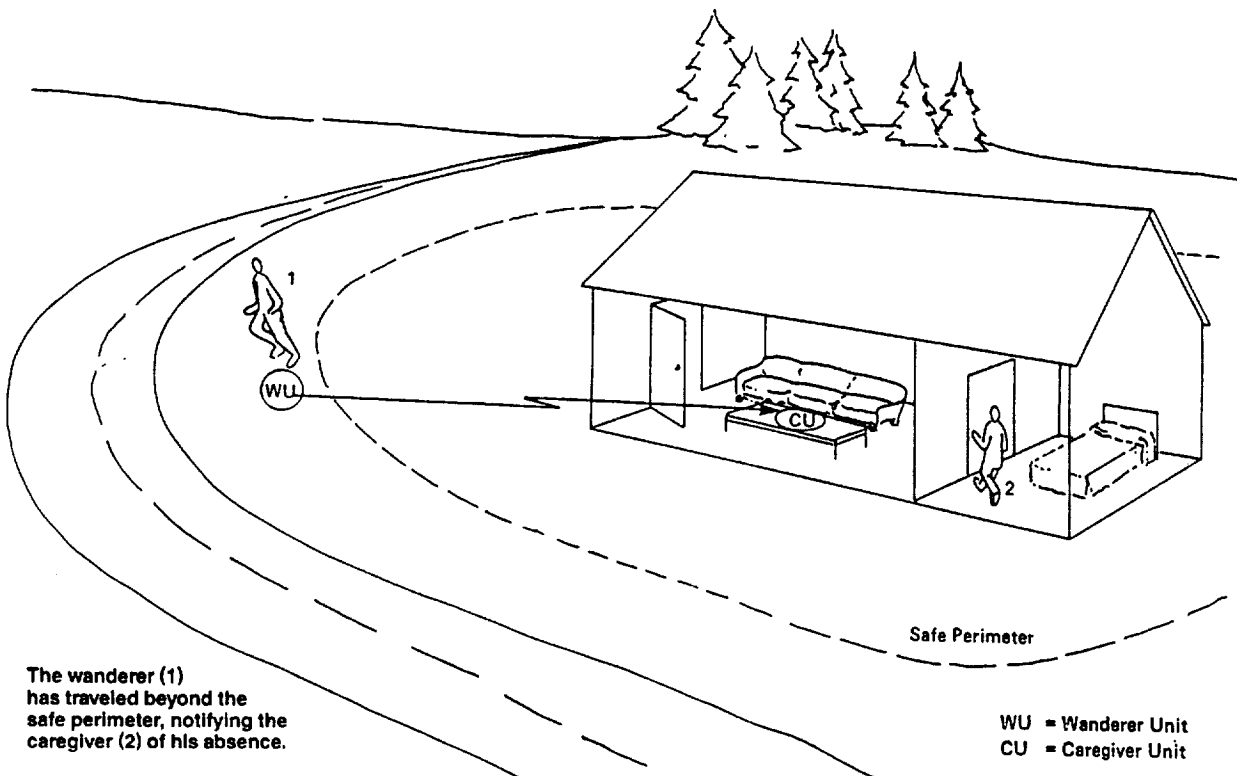


Figure 1. Home Wandering System — The safe perimeter.

In figure 2, the family caregiver is concerned about the wanderer going into a restricted area, which may also include going out the front door. Here, the passageway detector detects the ID tag and then notifies the caregiver's unit and possibly the wanderer himself.

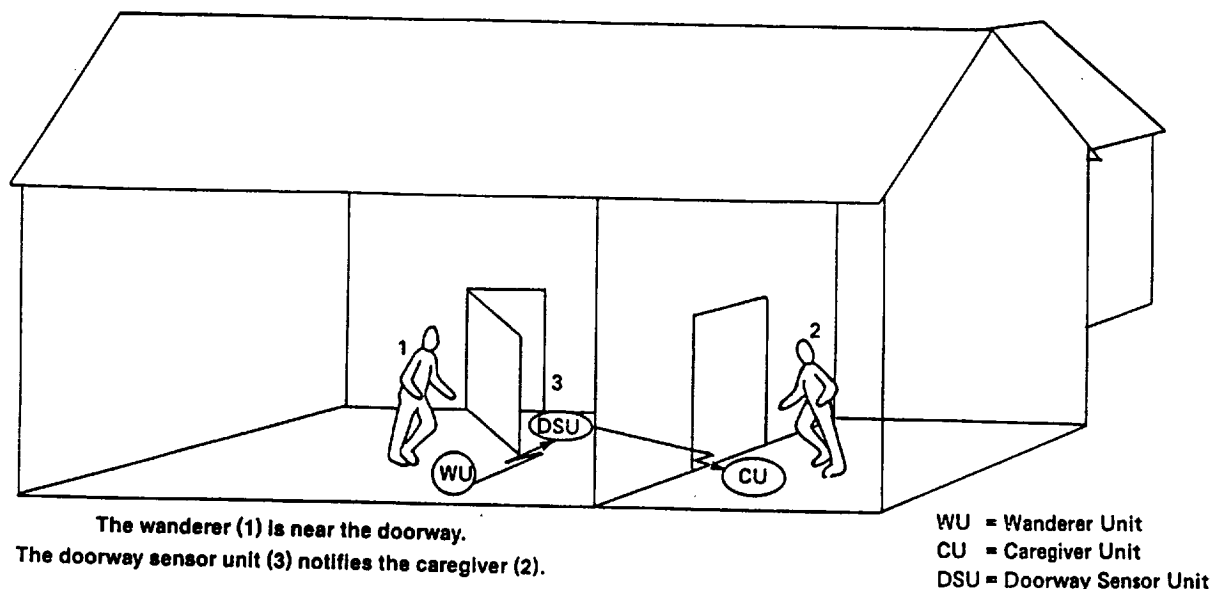


Figure 2. Home Wandering System — Passageway detection.

## DESIGN OF THE LOCATOR SYSTEM FOR WANDERING INDIVIDUALS

Based on the concept of the wandering notification system, the Locator System for Wandering Individuals was designed to provide communication and location monitoring or tracking of one or more wanderers in either the home or institutional setting. The system also permits a caregiver to monitor critical wanderer parameters such as wetness, motion, or a call for help.

The system configuration for the home is shown in figure 3. The basic configuration uses the ID tag, caregiver unit, and central control unit. The caregiver unit and ID tag have the same appearance to reassure the patient. Since the caregiver unit is portable, it permits considerable caregiver mobility while monitoring wanderer status via the central control unit. The caregiver may monitor various patient parameters and manually or automatically signal the patient. Up to four ID tags and four caregiver units can be used in the home system.

The institutional system is depicted in figures 4 and 5. Figure 4 shows the central processing unit (CPU); figure 5 illustrates the variety of sensors that are located throughout the facility. Sensor types consist of one central transmitter and multiple remote receivers, passageway detectors, and ID tags. The ID tags are worn by as many as 128 wandering patients and nurses. The central transmitter and one or more remote receivers permit wireless radio frequency communication between the nurses' station and nurse ID tags and the wandering patients as well as patient and nurse location monitoring on the CPU cathode ray tube (CRT). ID tag locations are determined by the remote receiver(s) indicating the presence of the ID tag based on the ID tag transmissions in response to polling by the central transmitter. This type of

locating is referred to as zonal tracking; ID tags are located within a particular zone based on the response at the remote receivers. Perimeter detectors prevent patients from wandering beyond established outdoor ranges since the zone defined by the perimeter detector is limited. Passageway detectors restrict access of all patients or select patients to certain areas based on the programmed acceptance of certain ID tag transmissions; an unauthorized ID tag transmission will cause an alarm to sound and also cause the nurses' station to alarm and identify the ID tag transmission. Should a patient wander away from the facility, the nurses' station is immediately alerted that the patient cannot be located in any zone and the patient may be traced and located with the portable homing unit.

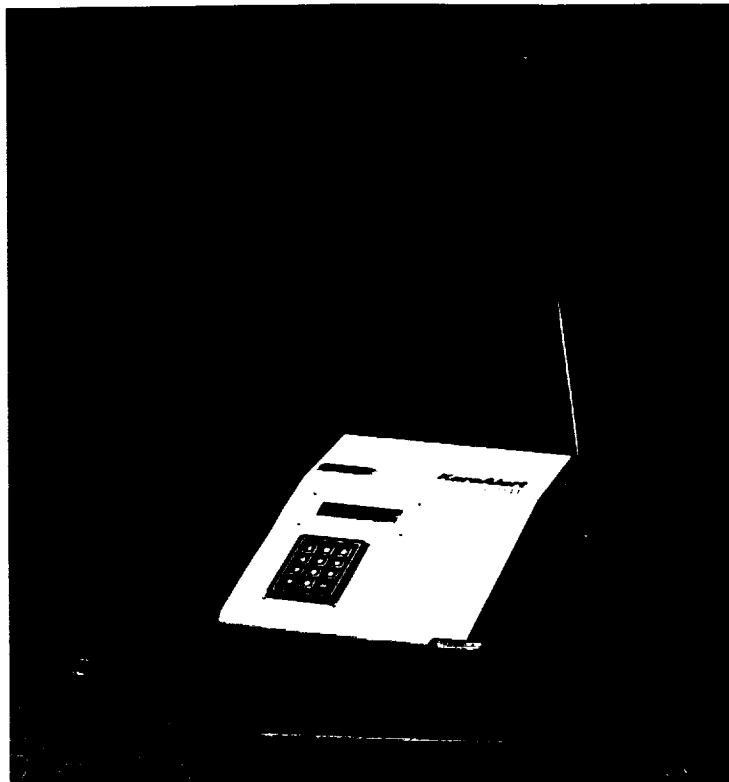


Figure 3.— Home Wandering System Configuration

ORIGINAL PAGE  
BLACK AND WHITE PHOTOGRAPH



Figure 4. – Central processing Unit for Institutional Wandering System

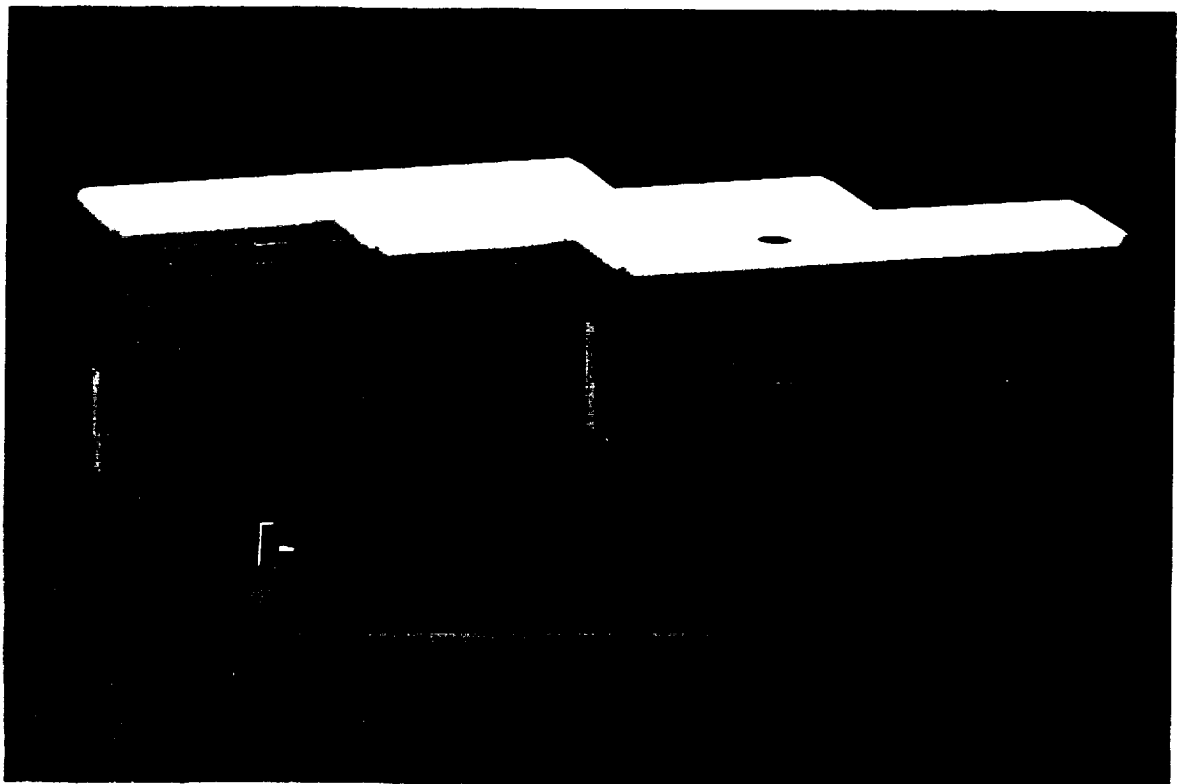


Figure 5.– Sensors for Institutional Wandering System



The CRT can display a variety of screens containing information on the wandering patients and system status. Figure 6 shows a basic facility floor plan with two wandering patients (designated 1 and 4) and one caregiver (designated 2). Patient 1 is not in the facility as expected, indicated by the red color of the icon. Patient 4 is present, as indicated by the light blue color of the icon. Caregiver 2 is in motion, as indicated by the light green color. Other status colors for icons are displayed in the legend to the right of the floor plan. The yellow field below the floor plan displays special status messages; patient 1 is noted as "lost" in figure 6. Figure 7 shows a similar display, with the caregiver 2 icon indicating a low battery condition (yellow icon).

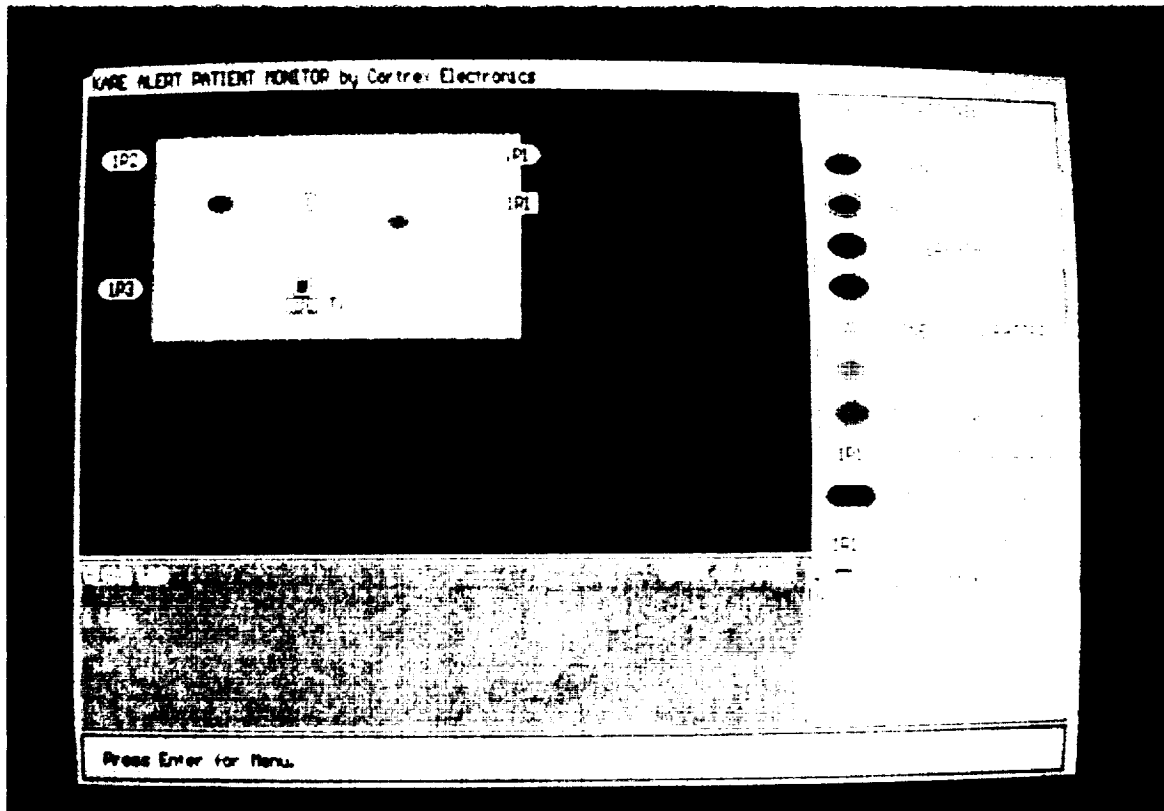


Figure 6. – Sample Facility Floor Plan

ORIGINAL PAGE  
COLOR PHOTOGRAPH





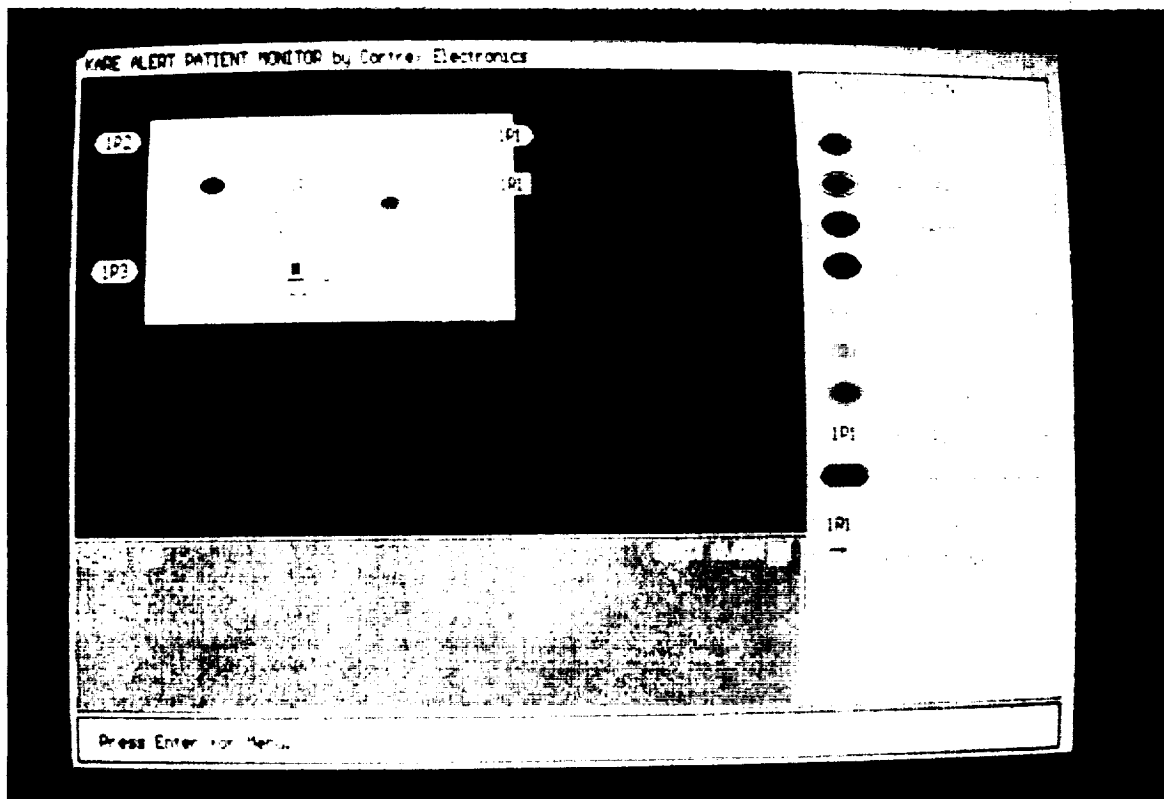


Figure 7. – Sample Facility Floor Plan - Low Battery Condition

ORIGINAL PAGE  
COLOR PHOTOGRAPH



Figure 8 shows the variety of parameters entered into the patient database by patient icon. Figure 9 shows the system test program. Tags 2 and 4 of the possible 128 are shown as functioning normally.

The image shows a computer screen displaying a patient database form. The form is titled "Patient Database" and contains the following fields:

- I.D.#: \_\_\_\_\_
- Last Name: \_\_\_\_\_
- First Name: \_\_\_\_\_
- Sex: \_\_\_\_\_ M for male, F for female
- Date of Birth: \_\_\_\_/\_\_\_\_/\_\_\_\_
- Weight: \_\_\_\_\_ pounds
- Height: \_\_\_\_\_ ft. \_\_\_\_ in.
- Admission Date: \_\_\_\_/\_\_\_\_/\_\_\_\_
- Medical Problems: \_\_\_\_\_
- Medications: \_\_\_\_\_
- Special Care: \_\_\_\_\_
- Observation Notes: \_\_\_\_\_
- Out Time: Day: \_\_\_\_ Date: \_\_\_\_/\_\_\_\_/\_\_\_\_ Time: \_\_\_\_:\_\_\_\_
- Passage Maps Permitted: \_\_\_\_\_
- Prohibited Zones: \_\_\_\_\_

Figure 8. - Patient Database

ORIGINAL PAGE IS  
OF POOR QUALITY

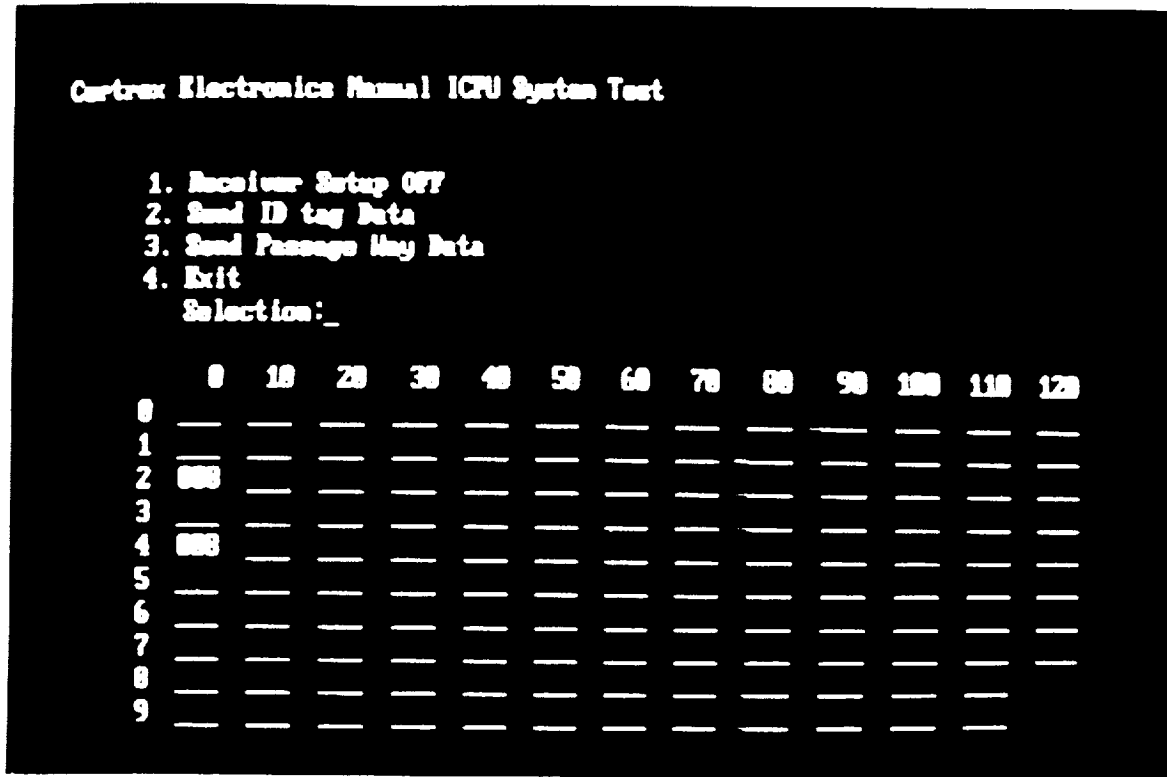


Figure 9. – Institutional Wandering System Test Program

The portable homing unit is shown in figure 10. This unit is the same as the central control unit used in the home configuration with the addition of a loop antenna used for direction finding. The ID tag signal is received by the portable homing unit and a signal strength indicator displays a bar when the ID tag is in range of the portable homing unit. The height of the bar indicates whether the ID tag is near or far away from the portable homing unit.

Use of a central control unit (in the home) or CPU (in the institution) allows tremendous system versatility, permitting the user to quickly custom-tailor the system to a given setting. Simple keyboard entries permit easy setup, changes in system function, or patient data acquisition.

The Locator System for Wandering Individuals was designed to be fail safe. The central control unit and CPU are constantly listening for ID tag signals. If an ID tag should fail and the signal cease, the caregiver is immediately alerted since the ID tag transmission is no longer present.

Two of the major challenges in development of the Locator System for Wandering Individuals were designing reliable wireless communication links and the very complex ID tag displayed in figure 11. A wireless communication link can be formed using optical, sonic, magnetic, electric, or radio frequency electromagnetic fields. Optical techniques may use non-coherent visible light, laser, or active infrared. Sonic methods include audible sound and ultrasonics. Optical and sonic fields are highly directional, are generally limited to less than 33 meters in range, and cannot penetrate walls. Magnetic or electric fields can penetrate walls, but are limited to very short range at reasonable power levels. Radio frequency was clearly the wireless link of choice and was therefore used in this application.

Because of its range and number of users, radio frequency use is controlled by the Federal Communications Commission (FCC), so that mutual interference may be minimized. Sections of the radio frequency spectrum referred to as "bands" are allocated for various types of communication. In selecting bands best suited for the wireless link, a number of factors were considered: FCC requirements and stability of rules, types of services now using the bands, radio frequency link efficiency with small antennas, effect of the human body or obstructions on link performance, and cost and complexity of receiver and transmitter.

Of all the system components, the ID tag design was the most challenging. It was a difficult task to incorporate radio frequency receivers, transmitters, microcontroller, logic, batteries, sensors, audio transducer and miscellaneous circuits into a watertight package not larger than a scientific calculator watch (see figure 11). In addition, the ID tag was required to support a communication range of several hundred feet and a battery life of six to eight weeks all at a price affordable to the average user. These goals were met by using a creative combination of commonly available components with surface mount technology (see figure 12).

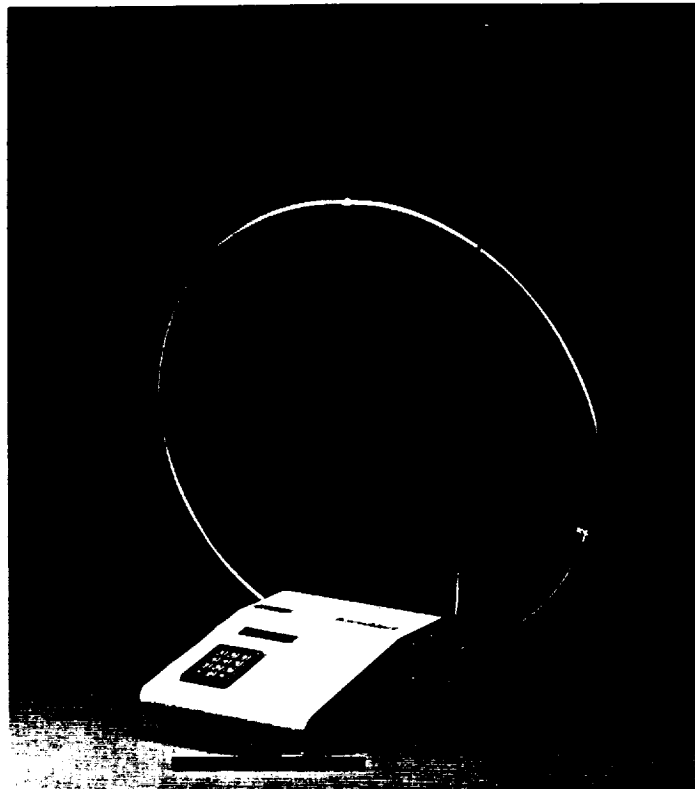


Figure 10. – Portable Homing Unit

ORIGINAL PAGE IS  
OF POOR QUALITY

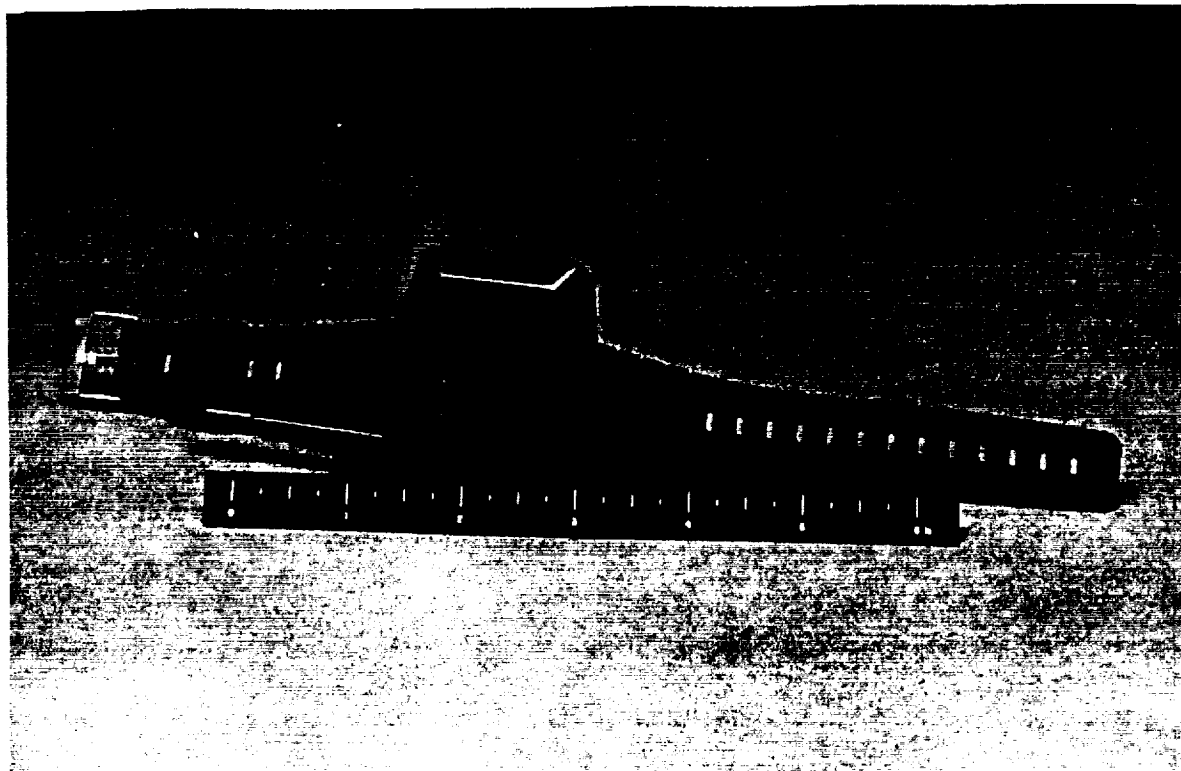


Figure 11. – Identification Tag

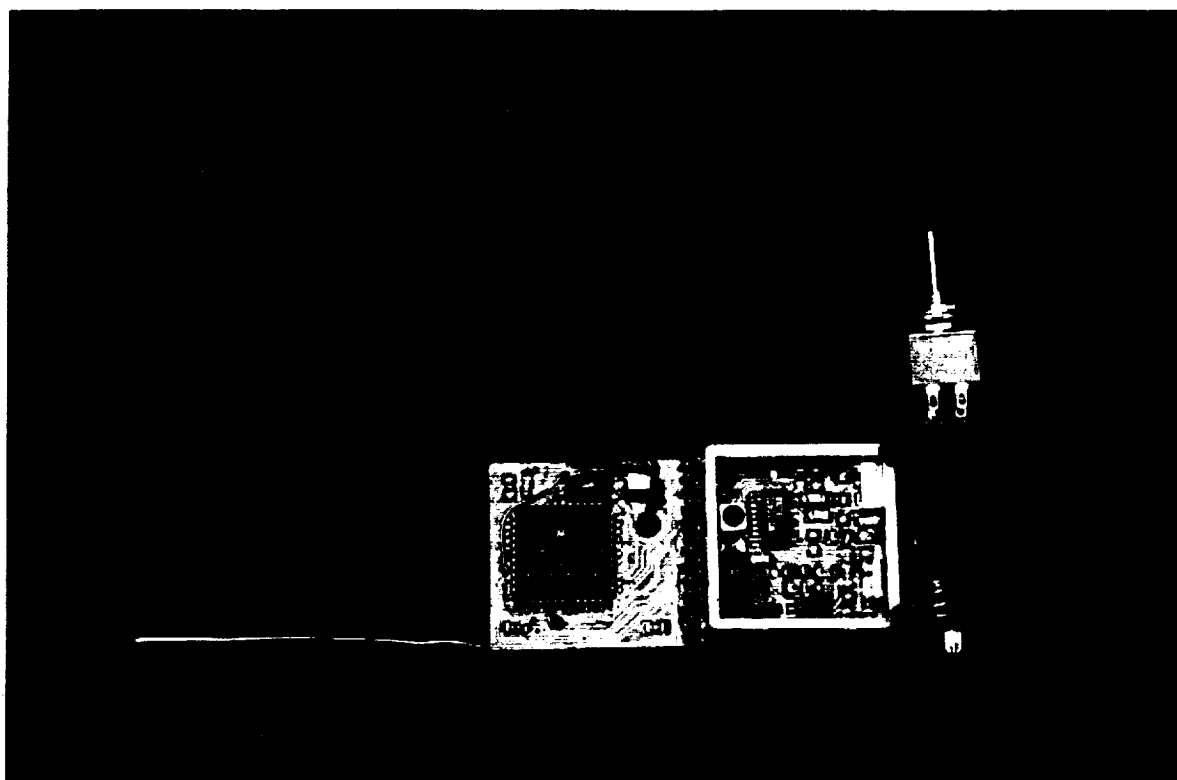


Figure 12. – Packaging of Identification Tag Components

## CONCLUSION

There is a growing awareness of and concern about problems of wandering in the memory-impaired elderly population. As expressed in the literature and reinforced by family caregivers, it is perhaps more desirable to allow for safe wandering than it is to completely restrict the behavior. There are coping strategies available that provide for some wandering. However, these strategies can easily stretch the physical and mental limits of a caregiver's already demanded time. Technologies that are becoming less expensive and more readily available should be incorporated into a system as part of a comprehensive wandering management program for caregivers.

Successful implementation of the Locator System for Wandering Individuals will depend on system availability, ease of use, and the features and benefits that will directly influence the purchasing decision. The following benefits have been identified for system use in the home setting: controlled freedom rather than enforced restriction for the wanderer; self-monitoring and memory training for some wanderers; security and peace of mind for family caregivers; reduced caregiver stress; signal locating and signal tracking should the older person become lost; additional prompting capabilities; and potential reduced or delayed need for institutionalization of the family member.

Cortex Electronics, NASA, and the other sponsoring government agencies believe that the Locator System for Wandering Individuals promises to be the best solution to care of the wandering patient in both the home and institutional environments.

## **REFERENCES**

Brody E: The Formal Support Network: Congregate Treatment Settings for Residents with Senescent Brain Dysfunction. In *Clinical Aspects of Alzheimer's Disease and Senile Dementia*, Miller N and Cohen G (eds), vol 15, Aging, Raven Press, New York, 1981, 301-331.

Burnside I: Wandering Behavior. In *Psychosocial Nursing Care of the Aged*, 2nd edition, McGraw-Hill Book Company, New York, 1980, 298-309.

Cohen H: Personal communication, 1986.

Cornbleth T: Effects of a Protected Hospital Ward Area on Wandering and Nonwandering Geriatric Patients. *Journal of Gerontology* 1977; 32(5):573-577 .

Davidson S, Skatvold A, Vories D, Rouse D, Winfield D: A Locator System for Wandering Individuals. Exploration: Technological Innovations for an Aging Population, Orlando, January 1989.

Fennelly A: Making it Safe for the Patient to Wander. *American Health Care Association Journal* 1985; November, 29-31.

George L: Caregiver Well-Being: Correlates and Relationships with Participation in Community Self-Help Groups. A Final Report submitted to the AARP Andrus Foundation, 1983.

Hiatt L: Disorientation is More than a State of Mind. *Nursing Homes* 1980; 29(4):30-26.

Hiatt L: The Environment as a Participant in Health Care. *Journal of Long-Term Care Admin* 1982; 10(1):1-17.

Hiatt L: The Happy Wanderer. *Nursing Homes* 1980; March/April, 29(2):27-31.

Hiatt L: Wandering Behavior of Older People in Nursing Homes: A Study of Hyperactivity, Disorientation and the Spatial Environment. Dissertation, The City University of New York, 1985.

Katzman R: Aging and Age-Dependent Disease: Cognition and Dementia. In *America's Aging: Health in an Older Society*, Committee on an Aging Society, Institute of Medicine and National Research Council, National Academy Press, Washington DC, 1985, 129-152.

Lawton P: Sensory Deprivation and the Effect of the Environment on Management of the Patient with Senile Dementia. In *Clinical Aspects of Alzheimer's Disease and Senile Dementia*, Miller N and Cohen G (eds), vol 15, Aging, Raven Press, New York, 1981, 227-251.



Mace N, Rabins P: *The 36-Hour Day: A Family Guide to Caring for Persons with Alzheimer's Disease, Related Dementing Illnesses, and Memory Loss in Later Life*. Baltimore and London, The Johns Hopkins University Press, 1981.

Miller J: Control of the Ambulatory Senile. *Concern* 1976; June-July, 34-37.

Oakley D: Senile Dementia — Some Aetiological Factors. *British Journal Psychiatry* 1965; III:414-419.

Rader J, Doan J, Schwab M: How to Decrease Wandering, a Form of Agenda Behavior. *Geriatric Nursing* 1985; July/August, 196-199.

Snyder L, Rupprecht P, Pyrek J, Brekhus S, Moss T: Wandering. *The Gerontologist* 1978; 18(3):272-280.

U.S. Bureau of the Census: *Statistical Abstract of the US* 1985. U.S. Government Printing Office, 1984.

# REPORT DOCUMENTATION PAGE

Form Approved  
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE  
August 1992

3. REPORT TYPE AND DATES COVERED  
Technical Memorandum

4. TITLE AND SUBTITLE  
The Locator System for Wandering Individuals

5. FUNDING NUMBERS

6. AUTHOR(S)  
Shayla Davidson

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)  
Tracking and Communications Division  
Lyndon B. Johnson Space Center  
Houston, Texas 77058

8. PERFORMING ORGANIZATION  
REPORT NUMBER  
S-688

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)  
National Aeronautics and Space Administration  
Washington, D.C. 20546-001

10. SPONSORING / MONITORING  
AGENCY REPORT NUMBER  
NASA-TM-104754

11. SUPPLEMENTARY NOTES  
A Technology Utilization Applications Engineering Project

12a. DISTRIBUTION / AVAILABILITY STATEMENT  
Unclassified/Unlimited Publicly Available  
  
Subject Category 54

12b. DISTRIBUTION CODE

13. ABSTRACT

Configurations and operation strategies are described for a wanderer locator system based on wireless radio frequency communication designed to monitor elderly patients who may wander beyond safe perimeters in the home or in an institutional setting. The modular components of this wandering notification system are (1) portable transmitter/receivers to be worn or carried by the patient and the caretaker, (2) detectors to be mounted in doorways or other perimeters of a safe area, (3) programmable central processing units to control, communicate with, and/or trace the portable and remote devices, and (4) a cathode ray tube that can display information on patient location or system status. Photographs of all system components and illustrations of operations concepts are included.

14. SUBJECT TERMS  
Position Indicators, Position Sensing, Position (Location),  
Aging (Biology), Human Factors Engineering, Human Behavior,  
Biotechnology, Man-Machine Systems

15. NUMBER OF PAGES  
19

16. PRICE CODE

17. SECURITY CLASSIFICATION  
OF REPORT  
Unclassified

18. SECURITY CLASSIFICATION  
OF THIS PAGE  
Unclassified

19. SECURITY CLASSIFICATION  
OF ABSTRACT  
Unclassified

20. LIMITATION OF ABSTRACT  
Unclassified